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Effect on Sensory Evaluation, Starch and *in vitro* Protein Digestibility in Cookies Supplemented by *Spirulina platensis* Powder

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ABSTRACT

Background: Cookies are the bakery product which is very much popular in different age groups. Sometimes cookies are used as supplement for meal, as munching, at traveling time, *etc.* Varieties of cookies are available in the market but some how they are deficient in nutrients. Therefore, the present study is focused on the development of nutrient rich and famous "cookies" supplemented with *Spirulina plantensis* powder, which is also known as super food; abundant in nutrients.

Methods: Cookies as functional foods were formulated using *Spirulina platensis* powder, wheat flour and bengal gram flour to explore their nutritional potential. For the formulation of composite flour, four different proportions of wheat flour, bengal gram flour and *Spirulina platensis* powder were used, *i.e* 50:50:0 (control), 49:49:2 (Type-I), 48:48:4 (Type-II), 47:47:6 (Type-III) and 46:46:8 (Type-IV). Supplemented cookies up to 6 per cent *Spirulina platensis* were found to be acceptable and were investigated further.

Result: The addition of *Spirulina platensis* powder to cookies, along with bengal gram flour and wheat flour, greatly improved the nutrient profile and digestibility of protein and starch.

Key words: Composite flour, Functional food, *Spirulina platensis,* Supplemented.

INTRODUCTION

The rising occurrence of illness caused by an unhealthy lifestyle, as well as the increasing value of a balanced diet in human life, highlight the need for natural and beneficial nutritional items. Nutrition is essential for the body's basic, inevitable functions. Numerous nutrition researchers have concentrated on naturally occurring components (*e.g.* vitamins, fatty acids, proteins, phenolic compounds and dietary fibre) in foods that have a beneficial impact on metabolic functions beyond nutritive value and provide health benefits, as well as potentially lowering disease risk.

In the last decade, global interest in functional foods has exploded. This revived interest is primarily due to the promised benefits of functional foods in the development of wellbeing and the prevention of illness. People are becoming more increasingly health - conscious, which is driving the rising economy of the health food industry today (Tupas 2020). The term functional foods refers to foods that contain biologically active compounds that have the potential to improve health or reduce the risk of serious illness, as well as to improve the radiance of life. A functional ingredient is a dietary ingredient that affects its host in a targeted manner in order to exert beneficial effects that support certain health claims. In other words, foods containing beneficial ingredients have health-promoting effects that reach far beyond their nutritional value (British Nutrition Foundation 2018).

Among the compounds with functional properties, dietary fibre is important because it can improve health by slowing digestion and absorption in the human gut and delaying gastric emptying time. Microalgae and seaweeds contain a diverse array of essential multifunctional bioactive compounds that may have health-protective properties. Furthermore, they can be excellent ingredients for the food industry in the production of value-added food products (Nova *et al.* 2020). *Spirulina platensis* is a well-known algae species. It (here after referred to as '*Spirulina platensis*') is a unicellular microalgae that grows in both fresh and salt water. *Spirulina platensis* contains approximately (60%) complete, highly digestible protein; it contains all essential amino acids; it contains more beta-carotene than any other whole food; it is the best whole food source of gamma linolenic acid (GLA); it is high in B vitamins, minerals, trace elements, chlorophyll and enzymes and it is rich in other nutrients such as carotenoids, sulfolipids, glycolipids, phycocyanin, superoxide dismutase, RNA and DNA (Capelli and Cysewski 2010).

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Spirulina platensis is an excellent food supplement for people who want to stay healthy. *Spirulina platensis* is sold as a dietary supplement or as an active ingredient in functional beverages all over the world. It has gained widespread recognition for the health benefits it provides. Algae biological activity research showed that they have antioxidant, antibacterial, antiviral and antifungal properties. A diet rich in algae fibre encourages the development and maintenance of beneficial intestinal flora. Algae also has prebiotic, neuroprotective, anti-inflammatory, immunomodulating, anti-diabetic, anticoagulant and anticancer properties (Charoensiddhi *et al.* 2018).

It has been seen that *Spirulina platensis* powder has enormous nutritional and health properties. Therefore, an attempt has been made to develop nutritious cookies with *Spirulina platensis* powder, as cookies are a popular bakery product among all age groups, especially among children and adolescents. Whereas, cookies are usually made up of processed flour and which lack fibre and other essential nutrients that are necessary for good health. Hence, the incorporation of microalgae into food products such as cakes and cookies can promote good health (Golmakani 2015). So, the current study has been designed to construct healthy cookies by mixing functional and nutrient-rich microalgae (*Spirulina platensis*) powder, Bengal gram flour and wheat flour.

MATERIALS AND METHODS

The current research was conducted between August 2017 and July 2019 at the Department of Foods and Nutrition, I.C. College of Home Science, Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.

Procurement of raw material

Wheat flour and bengal gram flour were obtained in a single lot from the Hisar local market. *Spirulina platensis* powder (food grade) was also purchased from the market. All of the samples were packaged in LDPE for future use.

Formulation of composite flour

For the development of composite flour, various proportions of wheat flour, bengal gram flour and *Spirulina platensis* powder were used. Cookies were made with wheat flour (100%) as a control. Four types of composite flours were prepared in the following ratios *i.e* 50:50:0 (control), 49:49:2 (Type-I), 48:48:4 (Type-II), 47:47:6 (Type-III) and 46:46:8 (Type-IV) using wheat flour, bengal gram flour and *Spirulina platensis* powder, respectively.

Formulations of cookies

Cookies were prepared by mixing different quantities of wheat flour, bengal gram flour and *Spirulina platensis platensis* powder (Chart 1). Table 1 lists ingredients with varying levels of concentration.

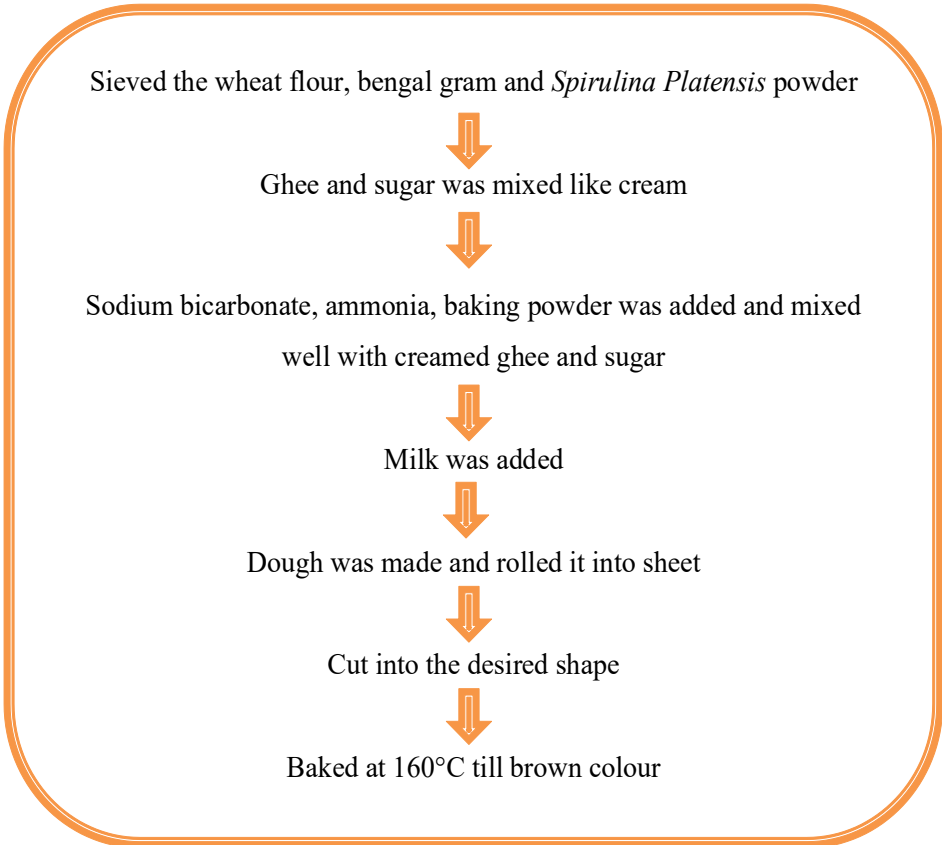

Chart 1: Flow diagram for development of cookies.

Organoleptic acceptability of developed nutrient rich cookies

Using a 9-point Hedonic scale, all types of cookies were organoleptically evaluated for colour, texture, appearance, taste and overall acceptability. Cookies were further tested for their various nutritional parameters based on sensory acceptability.

Nutritional analysis

Crude protein

The crude protein was measured using the (AOAC 2000 standard method) KEL PLUS Automatic Nitrogen Estimation System.

Crude fibre

Crude fibre in the sample was determined by employing the method of analysis (AOAC 2000).

Crude fat

Crude fat was estimated by standard method of analysis (AOAC 2000) using the Automatic SOCS Plus Solvent Extraction System.

Dietary fibre

Total, soluble and insoluble dietary fibre constituents were determined by the enzymatic method given by Furda (1981).

In vitro protein digestibility

In vitro protein digestibility was determined by the modified method of (Mertz *et al.* 1983).

In vitro starch digestibility

In vitro starch digestibility was assessed as per the method of (Singh *et al.* 1982).

Statistical analysis

The data obtained were analyzed statistically using standard methods of analysis (Sheoran and Pannu 1999).

RESULTS AND DISCUSSION

Sensory acceptance of nutrient rich cookies

Table 2 demonstrated the sensory acceptance of cookies. The panelists rated cookies made with Type-I composite flour as "very good." Cookies made with Type-II and Type-III flour, on the other hand, were rated as 'moderately liked' by the judges. Type-IV cookies were discovered to be 'neither liked nor disliked.' As a result, the sensory feature was deemed unacceptable. Overall acceptability scores of control cookies were 'liked very much' in terms of colour, appearance, aroma, texture and taste (Fig 2). The researchers discovered similar results in *Spirulina Platensis*-enriched bread, cookies and snacks. (Navacchi *et al.* 2012; Minh 2014; Saharan, 2017; Shinde *et al.* 2018).

Crude protein, crude fat and crude protein content

Wheat flour cookies (control) contained (11.28%) crude protein, (20.20%) crude fat and (1.57%) crude fibre. Although crude protein, crude fat and crude fibre content increased significantly with the addition of *Spirulina platensis* powder and bengal gram flour to three different types of composite flour-based cookies, because *Spirulina platensis* powder contained (71%) crude protein and bengal gram flour contained (20.20%) crude protein. In all three types of cookies, the values ranged from 17.89 to 21.49, 21.99 to 24.39, and 2.19 to 3.46 per cent, respectively. The highest contents were found in Type-III composite flour cookies,

Table 1: Different ingredients for cookies.

Supplementation level (%)	Ghee (g)	Milk (g)	Sugar (g)	CMC	Sodium bicarbonate (g)	Ammonia (g)
Control (100% WF)	40.0	40.0	60.0	a pinch	0.5	2.0
WF:BF:SP						
49:49:2 (Type-I)	40.0	40.0	60.0	a pinch	0.5	2.0
48:48:4 (Type-II)	40.0	40.0	60.0	a pinch	0.5	2.0
47:47:6 (Type-III)	40.0	40.0	60.0	a pinch	0.5	2.0
46:46:8 (Type-IV)	40.0	40.0	60.0	a pinch	0.5	2.0

WF= Wheat flour; BF= Bengal gram flour; SP= *Spirulina platensis* powder.

Table 2: Mean scores of sensory acceptance of cookies.

Types of cookies	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Control	8.60±0.32	8.40±0.23	8.50±0.67	8.50±0.21	8.60±0.16	8.52±0.16
Type-I	8.15±0.23	8.10±0.22	8.20±0.20	8.00±0.34	8.20±0.16	8.13±0.12
Type-II	7.75±0.15	7.55±0.80	7.65±0.11	7.85±0.19	6.85±0.21	7.53±0.07
Type-III	7.45±0.23	7.25±0.19	6.65±0.15	7.25±0.62	7.30±0.17	7.18±0.08
Type-IV	6.30±0.38	5.30±0.16	6.60±0.13	6.30±0.85	5.50±0.23	5.90±0.09
CD (p=0.05)	0.12	0.11	0.13	0.16	0.08	0.04

Values are mean±SE of ten panelists.

Type-I: WF: BGF: SP (49:49:2); Type-II: WF: BGF: SP (48:48:4); Type-III: WF: BGF: SP (47:47:6); Type-IV: WF: BGF: SP (46:46:8).

WF: Wheat flour; BGF: Bengal gram flour; SP: *Spirulina platensis* powder.

while the lowest were found in Type-I composite flour cookies. Table 3 contains the related data. Hence, the addition of bengal gram flour and *Spirulina platensis* powder in wheat flour may contribute to higher crude protein, crude fat and crude fibre contents in supplemented cookies.

Total dietary fibre

Wheat flour cookies had a total dietary fibre content of 8.24 g/100 g. Total dietary fibre content in supplemented cookies; Type-I, Type-II and Type-III, were increased significantly (p=0.05) as *Spirulina platensis* powder supplementation levels increased. The estimated dietary fibre content of composite flour cookies ranged from 9.73 to 10.99 g/100 g. Type-III cookies had the highest value (10.99 g/100 g) and Type-I cookies had the lowest value (9.73 g/100 g). The soluble dietary fibre content of control cookies was 2.20 g/100 g, which was found to be increased when *Spirulina platensis* powder was incorporated to wheat-bengal gram flour blends. Among the three types of supplemented cookies, Type-III cookies had the highest soluble fibre content (4.05 g/100 g), followed by Type-II cookies (3.53 g/100 g) and Type-I cookies (3.23 g/100 g). However, there were substantial (p=0.05) variations between the augmented cookies and the control cookies (Table 4). It may be because of the *Spirulina platensis* powder contains more soluble fibre. In terms of insoluble dietary fibre content, wheat flour cookies had 6.04 g/100 g insoluble dietary fibre, which increased slightly (p=0.05) with the amount of *Spirulina platensis* powder incorporation. Type-I, Type-II and Type-III cookies had values ranging from 6.50 to 6.94 g/100 g. Other researchers were also found similar results in *Spirulina Platensis* supplemented products (Abd EL-Baky *et al.* 2015 and Saharan 2017). It may be that *Spirulina Platensis* powder contains more dietary fibre.

Table 3: Crude protein, fat and fiber content of nutrient rich cookies (%, on dry matter basis).

Types of cookies	Crude protein	Crude fat	Crude fiber
Control (WF 100%)	11.28±0.12	20.20±0.17	1.57±0.11
Type-I	17.89±0.23	21.99±0.18	2.19±0.18
Type-II	19.27±0.25	23.27±0.16	2.99±0.13
Type-III	21.49±0.53	24.39±0.29	3.46±0.53
CD (p=0.05)	0.19	0.37	0.11

*On fresh basis; Values are mean±SE of three independent determinations.

Type-I: WF: BGF: SP (49:49:2); Type-II: WF: BGF: SP (48:48:4); Type-III: WF: BGF: SP (47:47:6).

WF: Wheat flour; BGF: Bengal gram flour; SP: *Spirulina platensis* powder.

Table 4: Dietary fiber content of nutrient rich cookies (g/100g, on dry matter basis).

Types of cookies	Total	Soluble	Insoluble
Control (WF 100%)	8.24±0.25	2.20±0.16	6.04±0.13
Type-I	9.73±0.41	3.23±0.69	6.50±0.31
Type-II	10.34±0.41	3.53±0.31	6.81±0.38
Type-III	10.99±0.41	4.05±0.52	6.94±0.43
CD(p=0.05)	0.82	0.07	0.03

Values are mean±SE of three independent determinations.

Type-I: WF: BGF: SP (49:49:2); Type-II: WF: BGF: SP (48:48:4); Type-III: WF: BGF: SP (47:47:6).

WF: Wheat flour; BGF: Bengal gram flour; SP: *Spirulina Platensis* powder.

Table 5: *In vitro* protein and starch digestibility of nutrient rich cookies (on dry matter basis).

Types of cookies	Protein digestibility (%)	Starch digestibility (mg maltose released/g)
Control (WF 100%)	63.42±0.06	53.28±0.09
Type-I	64.85±0.13	54.73±0.05
Type-II	65.79±0.05	55.79±0.07
Type-III	66.82±0.13	57.25±0.18
CD(P=0.05)	0.24	0.28

Values are mean±SE of three independent determinations.

Type-I: WF: BGF: SP (49:49:2); Type-II: WF: BGF: SP (48:48:4); Type-III: WF: BGF: SP (47:47:6).

WF: Wheat flour; BGF: Bengal gram flour; SP: *Spirulina platensis* powder.

***In vitro* protein and starch digestibility**

In vitro protein and starch digestibility content of control and *Spirulina platensis* supplemented nutrient rich cookies are presented in Table 5. Wheat flour cookies (control) had 63.42 per cent *in vitro* protein digestibility and 53.28 mg maltose released/g *in vitro* starch digestibility, which were significantly higher than all of the other composite flour-based cookies. *In-vitro* protein and starch digestibility ranged from 64.85 to 66.82 per cent and 54.73 to 57.25 mg maltose released/g, respectively, in composite flour-based cookies. The highest content was found in cookies made with Type-III composite flour, while the lowest was found in cookies made with Type-I composite flour. It might be due to higher amount of dietary fiber in *Spirulina platensis* powder *i.e.* total (14.98%), soluble (5.52%) and insoluble (9.46%) as these contents were significantly (p=0.05) higher as compare to wheat flour and bengal gram flour.

CONCLUSION

Based upon research results, it is reasonable to state that *Spirulina platensis* powder could be incorporated in wheat-bengal gram flour mixes up to (6%) without affecting sensory acceptance in cookies. Addition of *Spirulina platensis* powder in cookies improved the nutrient value and increased the digestibility of *in vitro* protein and starch. As a result, fiber-rich cookies with functional properties can help to regulate a specific body metabolism, such as strengthening biological defense mechanisms, preventing specific illnesses, regulating physical and mental conditions and delaying the ageing process. Consumption of such enriched food products containing *Spirulina platensis* will support the

malnourished demographic in the long run by improving their nutritional status. *Spirulina platensis*-fortified foods can be recommended to preserve functional health.

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